PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project

Yakima Basin Benthic Index Of Biotic Integrity (B-Ibi)

BPA project number: 20006
Contract renewal date (mm/yyyy): ☐ **Multiple actions?**

Business name of agency, institution or organization requesting funding
Washington Trout

Business acronym (if appropriate) WT

Proposal contact person or principal investigator:

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NPPC Program Measure Number(s) which this project addresses
7.1, 7.1A, 7.1B, 7.1E, 7.1I, 7.6, 7.6A, 7.6B4, 7.6C, 7.6D, 10.1, 10.2A1, 10.2C.

FWS/NMFS Biological Opinion Number(s) which this project addresses

Other planning document references
Draft report on Biologically-Based Flows for the Yakima River Basin: Recommendations, Section 4. Systems Operations Advisory Committee. 09/16/98.

Short description
Develop a multimetric Index of Biotic Integrity for the upper Yakima/Naches Basin using Benthic Macroinvertebrates to detect ranges of human impact on aquatic resource health.

Target species
Native resident and anadromous salmonids, other indigenous members of the fish community assemblage, native amphibians, aquatic macroinvertebrates (e.g., Plecoptera, Trichoptera, Ephemeroptera, Diptera, aquatic oligochaetes).

Section 2. Sorting and evaluation

Subbasin
Yakima

Evaluation Process Sort

CBFWA caucus	Special evaluation process	ISRP project type
Mark one or more caucus	If your project fits either of these processes, mark one or both	Mark one or more categories
☒ Anadromous fish ☒ Resident fish ☐ Wildlife	☒ Multi-year (milestone-based evaluation) ☐ Watershed project evaluation	☒ Watershed councils/model watersheds ☐ Information dissemination ☐ Operation & maintenance ☐ New construction ☒ Research & monitoring ☐ Implementation & management ☐ Wildlife habitat acquisitions

Section 3. Relationships to other Bonneville projects

Umbrella / sub-proposal relationships. List umbrella project first.

Project #	Project title/description
	Yakima Basin Fish-Habitat Population Studies
20006	Yakima-Basin B-IBI
20139	Comparative Population Study: Naneum, Coleman and Cooke Creeks

Other dependent or critically-related projects

Project #	Project title/description	Nature of relationship
	YSIS study of juvenile chinook gut-contents, % stomach fullness	Complementary; provides additional relevant data on food web ecology.
	YSIS salmon carcass "planting", nutrient-enrichment study	Complementary; provides additional relevant data, and will measure a significant response parameter of this YSIS project.
	Yakima Basin Reaches Study: Dr. Jack Stanford, USBR	Complementary; provides additional relevant data
	Timber, Fish and Wildlife state watershed analysis "Effectiveness	Complementary; provides additional relevant data.
	Monitoring &Evaluation Program", for part of upper Yakima Basin	

Section 4. Objectives, tasks and schedules

Past accomplishments

Year	Accomplishment	Met biological objectives?

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Develop multimetric index based on appropriate parameters of aquatic macroinvertebrate assemblage health for the Yakima subbasin	a	Sample benthos in 30 subbasin tributary and mainstem streams/rivers which encompass a range of conditions from near-pristine to degraded using standard protocol developed by Dr. James Karr for obtaining a region-specific benthic index of biotic integrity.
		b	Sort and identify to genus all samples obtained under task (a).
		c	Classify sorted samples along gradients/metrics likely to provide consistent signal of biotic condition and human impact on biotic condition (e.g., taxa richness/composition, # or % tolerant and intolerant species, # or % predator taxa).
		d	Evaluate candidate metrics constructed in task c to arrive at a multimetric index which consistently reflects and accurately predicts the response of stream system biotic health to human landscape impacts of concern.
2	Monitor and evaluate sample streams and sites on an annual basis to evaluate/refine multimetric index and to detect and evaluate the biotic response	a	Same as tasks 1(a-d) above.

	of streams and sites to natural disturbance events and human-caused landscape impacts, including managemen		
3	Communicate results of B-IBI development and annual monitoring to managers, stakeholders, and other interested parties in and outside of the Yakima subbasin.	a	Write reports, publish peer-reviewed articles, give presentations to managers in the subbasin such as USBR, YIN, WDFW, DNR, USFS, DOE, CBFWA and to watershed groups.
4	Integrate results into other research programs undertaken in the subbasin under related present or future umbrella proposals/projects.	a	Make results known and available to research/monitoring projects ongoing or undertaken in subbasin watersheds of sampled streams, including specific stream research projects, Yakima Species Interaction Studies, forest practices monitoring under TFW, and
4	continued		reach studies sheduled to be initiated under the direction of Dr. Jack Stanford and funded by the USBR.

Objective schedules and costs

Obj #	Start date mm/yyyy	End date mm/yyyy	Measureable biological objective(s)	Milestone	FY2000 Cost %
1	9/2000	3/2001		Report on results of initial year, 05/2001	40.00%
2	9/2001	3/2005		Semi-annual reports: 05/2003 and 05/2005.	0.00%
3	1/2001	10/2001		none	60.00%
4	3/2001	5/2005		Semi-annual reports: 05/2003 and 05/2005.	0.0
				Total	100.00%

Schedule constraints
Field sampling should be done during lowflow conditions, from late August to early October. Sampling 3 replicates per site for 30 sites normally requires 20 to 30 field days. A 60 day window for field work will ensure sampling of all sites.

Completion date
5/2005.

Section 5. Budget

FY99 project budget (BPA obligated):

FY2000 budget by line item

Item	Note	% of total	FY2000
Personnel	Sample collection, sample sorting and metric devlopment, literature searches and report writing.	%47	22400
Fringe benefits	@25%	%12	5,600
Supplies, materials, non-expendable property	Sampling supplies and related office supplies	%3	1,410
Operations & maintenance	Vehicle maintenance	%2	1,000
Capital acquisitions or improvements (e.g. land, buildings, major equip.)	Field and lab. equipment (incl. 1 microscopes, 4 temp loggers, and 1 laptop PC)	%12	5,800
NEPA costs		%0	
Construction-related support		%0	
PIT tags	# of tags:	%0	
Travel	Mileage,food, lodging, 1 pack trip	%8	3,850
Indirect costs	20% of non-subcontract sub-total	%17	8,012
Subcontractor		%0	
Other		%0	
		TOTAL BPA FY2000 BUDGET REQUEST	$48,072

Cost sharing

Organization	Item or service provided	% total project cost (incl. BPA)	Amount ($)
University of Washington	Supervision of graduate student and general project advice by Dr. James Karr.	%11	6,000
University of Washington	Laboratory facilities under the direction of Dr. James Karr	%0	NA
		%0	
		%0	
		Total project cost (including BPA portion)	$54,072

Outyear costs

	FY2001	FY02	FY03	FY04
Total budget	$40,000	$42,000	$48,000	$50,000

Section 6. References

Watershed?	Reference
☐	Karr, James R., and Ellen W. Chu. 1997. Biological Monitoring and Assessment: Using Multimetric Indexes Effectively. EPA 235-R97-001. University of Washington, Seattle.
☐	Karr, James R., 1998. "Salmonweb Biological Monitoring Protocol", vhs tape.Also available from website "www.salmonweb.org".
☐	Norris, R.H., E.P. McElvray and V.H. Resh. 1994. "The Sampling Problem". Reprinted in "River Biota", selected extracts from The Rivers Handbook. Geoffrey Petts and Peter Calow, eds.Blackwell Science Ltd., 1996.
☐	Gore, J.A., 1994. "Response of Aquatic Biota to Hydrological Change". Reprinted in "River Biota". Geoffrey Petts and Peter Calow, eds. Blackwell Science Ltd. 1996.
☐	Fore, Leska S., James R. Karr, and Robert W. Wisseman. 1996. "Assessing invertebrate responses to human activities: evaluating alternative approaches". Journal of the North American Benthological Society, 15(2): 212-231.
☐	Merritt, R.W., V.H. Resh, and K.W. Cummins. 1996. "Design of Aquatic Insect Studies: Collecting, Sampling and Rearing Procedures." In An Introduction to the Aquatic Insects of North America, Third Edition. Kendall/Hunt Publishing Company, Dubuque, Iowa.
☐	Rosenberg, D.M. and V.H. Resh. 1996. "Use of Aquatic Insects in Biomonitoring". In Merrit and Cummins (eds.) An Introduction to the Aquatic Insects of North America, Third Edition.
☐	Hauer, F. Richard and Vincent H. Resh. 1996. "Benthic Macroinvertebrates". In Methods in Stream Ecology, F. Richard Hauer and Gary A. Lamberti (eds.) Academic Press.
☐	Merritt, Richard W., and Kenneth W. Cummins. 1996. "Trophic relations of Macroinvertebrates". In Methods in Stream Ecology, F. Richard Hauer and Gary A. Lamberti (eds.). Academic Press.
☐	Resh, Vincent H., Marilyn Myers, and Morgan J. Hannaford. 1996. "Macroinvertebrates as Biotic Indicators of Environmental Quality". In Methods in Stream Ecology.
☐	Hauer, F. Richard, John Gangemi, and Jack A. Stanford. 1994. "Long-Term Influence of Hungry Horse Dam Operation on the Ecology of Macrozoobenthos of the Flathead River." Open File Report #133-94, Flathead Lake Biological Station, University of Montana.
☐	Hauer, F. Richard and Jack A. Stanford. 1997. "Long-Term Influence of Libby Dam Operation on the Ecology of Macrozoobenthos of the Kootenai River, Montana and Idaho." Open File Report 141-97. Flathead Lake

	Biological Station, University of Montana.
☐	Karr, James R. 1998. "Rivers as Sentinels: Using the biology of rivers to guide landscape management." In R.J. Naiman and R.E. Bilby, eds. The Ecology and Management of Streams and Rivers in the Pacific Northwest Coastal Ecoregion. Springer-Verlag, NY.
☐	

PART II - NARRATIVE

Section 7. Abstract

Assessment of aquatic and related landscape habitat at the watershed and finer scales requires the development/application of inventory and assessment measures capable of detecting departures from normative habitat conditions/processes and of detecting the impact of human activities which are or are reasonably thought to be causes of such departures from a normative condition. Bioassessment methods are essential to such assessment, but have yet to be consistently and systematically used in implementation of the FWP.

Unlike measurement of habitat impacts based on monitoring of chemical and physical criteria which provide snapshots of condition, biologically-based assessment methods are capable of integrating human impacts through time. Specifically, the use of biological assessment based upon aquatic benthic macroinvertebrates is particularly suitable to evaluating human-caused landscape impacts on aquatic environments in the Pacific Northwest.

We propose to develop and employ a multimetric Benthic Intex of Biotic Integrity (B-IBI) for the Yakima River subbasin. B-IBIs are significantly accurate and robust at detecting human-caused impacts when the array of metrics employed are specifically chosen and evaluated at the watershed scale. 30 stream and mainstem segments encompassing a range and variety of conditions from near-pristine to severely degraded will be sampled using standard benthic sampling protocols developed and evaluated by Dr. James Karr and colleagues specifically for use in developing watershed/georegion-specific B-IBIs. Test metrics will be evaluated to determine an appropriate array of metrics to employ in a robust multimetric index applicable to the Yakima subbasin.

Section 8. Project description

a. Technical and/or scientific background

A significant part of the decline and loss of native resident and anadromous salmonids in the Columbia River Basin is attributable to the loss, impairment, and/or alteration of normative ecosystem habitats and processes. Preservation and recovery efforts are increasingly being focussed on maintenance and recovery of these conditions and processes. A necessary and implicit assumption of such efforts is that assessment methods are able to distinguish natural dynamic changes in habitat conditions from changes which are due to human activities that are disruptive of normative conditions and processes. This requires that assessment methods are capable of detecting signals in the landscape environment and assigning human activities to these signals as cause to effect. Appropriate assessment methods must be employed both for signals of environmental impairment and for signals of recovery of normative condition and process.

One of the most useful types of assessment methodology is bio-assessment and bio-monitoring. Since approximately the early 1980s various bio-assessment methodologies have been tested and employed to various degrees across the country, and several adopted by regulatory agencies, principally by the US Environmental Protection Agency (EPA) and a few state departments of environmental quality, those, e.g., in Ohio and in Oregon. (See Karr 1998 and Karr and Chu 1997 and references therein.)

With appropriately constructed protocols, bio-assessment offers a significant advantage in aquatic resource assessment compared to traditional chemical- and physical-parameter water quality assessments. These latter provide time-slice snapshots of condition, and generally are incapable of reflecting and integrating landscape impacts on aquatic resources over time. Bio-assessment methods, on the other hand, are inherently capable of reflecting/integrating cumulative impacts both spatially and temporally. Biological entities such as fish and macroinvertebrates (but also zooplankton and periphyton) reside in the aquatic environment over significant time periods. Both individual species and community characteristics reflect responses to changes in the aquatic environment. Moreover, details of these species- and community-level responses can be partitioned so as to detect (provide a signal of) natural and human sources of landscape changes and their consequent impacts upon the aquatic environment.

Several recent studies indicate that multi-metric indices applied to benthic macroinvertebrates (B-IBIs) are most sensitive and robust for bio-assessment of landscape impacts upon aquatic resources in the Pacific Northwest. (See, for example, Karr 1998, Karr and Chu 1997, Fore et al., 1994, and references therein.)

Multi-metric indices are constructed from individual metrics chosen to reflect both individual taxa and biotic community response to human-caused impacts on the aquatic environment. Metrics are chosen from among four general classes: taxa richness and composition, taxa tolerance/intolerance, feeding ecology, and population attributes such as taxa dominance and abundance. Individual metric scores are tested and calibrated to reflect the response of biota to a range of human impacts on the integrity of the aquatic environment from pristine/minimally disturbed to severely degraded. The scores of individual indices across the full range of impacts are partitioned into quartile ranges (three in the case of the B-IBI) and simple integer scores (1, 3, and 5 in the case of B-IBI) assigned to each quartile. Scores for the individual indices are added together to produce a single overall multi-metric score. Sites are subsequently ranked within the range of conditions identified (from pristine to severely degraded) according to the overall multimetric score.

Such multi-metrics can be tested with familiar statistics, such as ANOVA and regression, because they allow analysts to take advantage of the properties of the mean, while keeping the information contained in the component index scores readily available. They allow simple and informative graphical analysis of the data and communicate clear summary information to managers and stakeholders without them having to be prepped in basic or multivariate statistics. Further details on the construction of a multi-metric B-IBI are given in subsections (e) and (f) below.

Most indices of aquatic and landscape habitat conditions, like simple common sense intuition, are good at identifying pristine or minimally disturbed sites and severely degraded ones. The difficult and important task is to identify moderately impacted sites, identify types of probable causes of their impairment, and measure their often gradual response to corrective actions. Multi-metric indices of biotic integrity appear to be most capable of this kind of measurement. (See, for example, Fore, et al, 1994, Karr and Chu 1997, and Karr 1998 and related references therein.)

Despite the relatively widespread and growing interest in and use of bioassessment methods previously noted , systematic bioassessment has not been employed in the implementation of the FWP in the Columbia Basin. Washington Trout proposes to remedy this by initiating a project to develop a Benthic Index of Biotic Integrity (B-IBI) for the Yakima and Naches River Basins. Such an Index would likely be applicable with little modification to other subbasins of the mid- and upper-Columbia in Washington State.

The Yakima/Naches River Basins are subjects of significant anadromous salmonid recovery efforts under the FWP, suffer from and reflect a variety of landscape impacts, including river regulation, irrigation, grazing, timber harvest, and urbanization, and contain a variety of landscape/aquatic habitats and microgeoclimatic regimes. Significant recent initiatives -- by NPPC/CBFWA under the Yakima Fisheries Project and through the Bureau of Reclamation under Title XII Water Enhancement legislation of 1994 – are and/or soon will be undertaken with the aim of restoring normative river conditions and wild anadromous salmon as essential components of a normative river ecosystem.

Central to the restoration/establishment of normative conditions in the Yakima subbasin is the redevelopment of productive normative aquatic food webs across scales of stream order. Benthic macroinvertebrates are fundamental, central, components of the aquatic food webs of both resident and anadromous native salmonids. Proper evaluation and monitoring of specific projects likely to be undertaken in connection with or complementary to the above-mentioned initiatives require the employment of a monitoring protocol capable of measuring the response of benthic macroinvertebrates.

Properly constructed, a B-IBI can serve to evaluate aquatic resource condition across a range of scale of stream orders and to identify likely sources of impairment across the landscape, provide a reliable index of aquatic resource response to preservation and restoration measures, and contribute to the assessment of the status of aquatic food webs from a normative ecological perspective.

b. Rationale and significance to Regional Programs

Preservation and restoration of aquatic, riparian, and upland habitat and ecosystem processes is a fundamental component of the Fish and Wildlife Program’s strategy for the preservation and recovery of the integrity and diversity of the native resident and anadromous salmonid species of the Columbia Basin (See Sections 7 and 10 of the 1994 FWP.) The concept of normative river ecology, as articulated in the ISG’s Return to the River, has been acknowledged by the Council as providing a conceptual framework necessary to give coherence and direction to the Basin's commitment to adaptive ecosystem management in the implementation of the FWP.

Essential to the framework of normative ecology is a proper assessment of watershed conditions as a prerequisite to the undertaking of specific habitat preservation and restoration initiatives. The FWP makes a strong commitment to thorough, meticulous watershed assessment (Section 7.6C, p. 7-35), a commitment the importance of which was strongly emphasized by the ISRP in its recent Review of the FWP for Fiscal Year 1999 (ISRP 98-1, June 15, 1998, page 15.). The FWP is unambiguous in emphasizing the need "to assess watershed health on a stream-reach-by-stream reach basis" and for peer review of assessment methodologies and results. "Only with such assessments can recovery plans be designed for the needs of each stream." (FWP, loc. sit.)

Watershed assessment methodologies applicable at stream-reach and larger scales not only must be employed as prerequisites to the implementation of normative preservation/recovery measures and plans. The methodologies thus employed must be capable of identifying a range of impairments (a range of departures from normative conditions), and of distinguishing between those that are caused by natural environmental stochasticities and those that are caused by human activities on the landscape, activities moreover which are often heterogeneous and cumulative in their impacts.

In addition to such assessment, related assessment methodologies employed in monitoring must be capable of identifying a range of changes in habitat conditions subsequent to preservation/recovery actions and of appropriately characterizing such changes as "responses to" those actions. Such sensitivity in assessment and monitoring methodologies is particularly critical for that range of habitat conditions which fall under the broad category of "moderately-impaired". Such moderately impaired habitats are generally the most numerous among candidates for protection from further degradation and for receipt of specific, generally costly, recovery actions; and they present managers with the most difficult, yet probably most important, issues of prioritization for the commitment of scarce restoration dollars.

Bio-assessment in general, and the Benthic Index of Biotic Integrity in particular, has considerable promise as a fundamental assessment methodology with a unique capability for separating human-caused impairment of aquatic and landscape habitat from natural variability, and of accurately scaling both impairments and responses to management actions across the range of conditions from severely degraded to pristine. It holds special promise of being successful in scaling impairments and responses within that qualitative and critical range of conditions aptly characterized "moderately impaired".

In addition to the issue of watershed assessment, the B-IBI is relevant to the general concern of Sections 7 and 10 of the FWP to protect and improve the productivity of native resident and anadromous salmonids and their habitats. Precious little is known about freshwater food webs essential to salmonids and their historic diversity in the Basin. Nor is much really known regarding the feeding ecology of juvenile anadromous salmonids, particularly chinook and steelhead. Based upon what we do know, it is surely reasonable to hypothesize that benthic macroinvertebrates are both essential food items as well as critical components of the food webs which underlay the freshwater productivities of salmonids throughout subbasins of the Columbia.

It is essential, however, that we improve our understanding of the food webs of juvenile anadromous salmonids and of resident salmonids and refine our understanding of the role of benthic macroinvertebrates in those webs. The B-IBI can add considerably to this basic understanding in the process of accomplishing the assessment objectives discussed above. Of special significance, the B-IBI does this in a manner which minimizes, to the extent that this is reasonably possible, the requirement for sample collection and evaluation (See, loc. sit.) These requirements, known as "the sampling problem", occasion considerable discussion and debate among aquatic ecologists. There is an extensive and sophisticated literature on the statistical issues of sampling freshwater biota. (See, for example, Norris, McElvray, and Resh, 1994, and Merritt, Resh, and Cummins, 1996 and references therein, in addition to those previously cited.) The sampling protocol is discussed in subsections "e" and "f" below.

Both these features of the B-IBI – assessment of a range of human impacts over a range of habitat conditions, and enhancing knowledge of the composition and condition of benthic foodwebs – would add a significant new dimension to the execution of the FWP and would directly further the goal of understanding what is required to achieve normative conditions in subbasin watersheds.

c. Relationships to other projects

B-IBIs have been developed during the past 5 years by students and colleagues of Dr. James Karr for SW Oregon (Fore et al., 1996), Eastern Oregon (Fore et al., unpublished manuscript; cited in Karr and Chu, 1997, p. 103), northwestern Wyoming (Patterson 1996), and Puget Sound, Washington State (Kleindl 1995). The eastern Cascades of Washington, and the Yakima Basin in particular, possess unique geological and climatological features which make it reasonable to expect that differences in benthic macroinvertebrate assemblages across a range of similar disturbance conditions will be encountered in comparison to Oregon, Wyoming and Puget Sound. The development of a B-IBI for the Yakima Basin/Eastern mid-Columbia Cascades will complement and enrich the scientific understanding of the response of aquatic biota to disturbance, and will help lead to increased power in the use of B-IBIs for the kinds of assessment and monitoring noted above.

The project will provide additional useful information in understanding and assessing the status of native resident salmonid populations surveyed in FY1998 under Project #98-026.

The Yakima Species Interaction Studies (YSIS) Program initiated a study in FY1998 of stomach contents and percent of gut fullness of juvenile spring chinook. Results from a B-IBI will likely provide invaluable and complementary information to the study's results.

YSIS is also planning and will initiate a program of selective "planting" of hatchery chinook salmon carcasses in several subbasin tributaries in the Naches and upper Yakima Basins. The study will aim to analyze and evaluate the impact of carcass-laden ocean-derived nutrients on stream productivity. Results from a B-IBI will be directly relevant to such studies and complementary to them.

The Bureau of Reclamation, Yakima Division, under the advice of the Systems Operations Advisory Committee (SOAC), has recently contracted with Dr. Jack Stanford, Director of the University of Montana's Flathead Lake Biological Station, to undertake normative ecological studies of selected reaches in the Naches, Upper Yakima, and Yakima mainstem below the confluence of the Naches to evaluate and prioritize restoration/preservation options. A post-doctorate student who will conduct this research under Dr. Stanford's direction has recently been hired and is now in residence at Central Washington University. A B-IBI is not specifically

planned in connection with these studies. Results of a B-IBI are complementary to the aims of these studies. Dr. Stanford is aware and supportive of this proposal by Washington Trout.
A state Watershed Analysis “Effectiveness Monitoring and Evaluation Program” under the Timber, Fish, and Wildlife Forum has recently been initiated in parts of the upper Yakima Basin. Results of a B-IBI will be relevant to such a program and complementary to its aims and purposes.

d. **Project history** (for ongoing projects)

(Replace this text with your response in paragraph form)

e. **Proposal objectives**

General, overall, objectives:

1. Develop and validate a concise, accurate multi-metric Benthic Index of Biotic Integrity (B-IBI) for the Yakima subbasin which will permit the assessment of human-induced landscape impacts on stream aquatic condition.
2. Through the proposed project and through collaboration and interaction with other projects throughout the Yakima subbasin demonstrate the effectiveness of the B-IBI as both an assessment and a monitoring tool for watershed activities and projects, and consequently encourage the use of the B-IBI as a basic and essential assessment and monitoring tool for such projects both in the Yakima and throughout the Columbia Basin.
3. Through collaboration and interaction with appropriate projects in the Yakima subbasin, including related projects by Washington Trout proposed for FY2000 under an umbrella proposal, demonstrate the effectiveness of the B-IBI as a tool for understanding food webs in subbasin tributary streams.

Immediate objectives related to project development:

1. Select 30 riffle sample sites from a minimum of 20 subbasin tributaries of the Upper Yakima, Naches, and mainstem Yakima downstream to and including the Satus Creek subbasin, and from sites on the Upper Yakima, Naches, and Yakima mainstem downstream of the confluence of the Naches. Choose sites so as to encompass a full range of stream habitat conditions ranging from “pristine/nearly-undisturbed” to “severely degraded” and including a broad range of intermediate-disturbance conditions (“moderately-disturbed”) resulting from a representative range of human landuse impacts on stream health and physical condition.
2. Annually, during baseflow conditions between late August and mid-October, but preferably within a single 30-day period, collect benthic invertebrate samples from 3 replicate sites within each of the 30 riffle sites (total of 90 replicates per season/year) using a standard benthic sampling protocol developed by Dr. James Karr specifically for B-IBI (in Karr and Chu 1997, Box 2, page 79, and available on vhs from salmonweb or on the website, www.salmonweb.org. See also subsection “f”).
3. Completely enumerate benthic invertebrates from each replicate and identify to genus.

4. Categorize the benthic invertebrate populations of the replicate samples and sites according to candidate metrics (indexes) from the categories of **taxa richness and composition, tolerants and intolerants, feeding and related habits**, and **population attributes** (see below).
5. Evaluate individual metrics for sensitivity in reflecting/detecting levels of impairment of aquatic condition due to human-caused landscape impacts.
6. Choose a subset of the most sensitive individual metrics to combine into a multi-metric Index of Biotic Integrity which integrates a range of basic population-level invertebrate responses to environmental variation and disturbance.
7. Employ the resulting Benthic Index of Biotic Integrity to monitor changes in biotic condition of sampled streams over the five-year project period and to identify putative (contributing) causes for those changes.
8. Refine the Index based on results from 7.

Hypotheses to be tested:

a) Indices of taxa richness and composition will decrease monotonically as stream habitat conditions are disturbed/degraded from human activities, with the exception of chironomid taxa. (See letter "e)" below for enumeration of specific candidate indices.)
b) Indices of tolerant taxa will increase along a gradient of human-caused disturbance and those of intolerant taxa will decrease along a similar gradient.
c) Indices of feeding and related habits will respond along the gradients of human disturbance in mixed ways. Indices such as "% predators" and "clinger taxa richness" will decrease with increasing disturbance. Indices such as "% scrapers", "% gatherers", "% filterers" will increase with disturbance.
d) Indices of population attributes such as "abundance" will respond in a variable fashion. "Dominance" defined as, for example, "the % of the 3 most numerous taxa", will increase, either monotonically or asymptotically as disturbance increases.
e) The resulting B-IBI will consist of 10 to 12 of the following:

    Total number of taxa
    Number Ephemeroptera taxa
    Number Plecoptera taxa
    Number Trichoptera taxa
    Number of long-lived taxa (e.g., Perlid and Pteronarcyd stoneflies)
    Number of intolerant taxa
    Number of sediment-intolerant taxa
    % tolerant taxa
    % sediment-tolerant taxa
    % oligochaetes
    % predators
    Clinger taxa richness
    % scrapers
    % shredders
    % filterers
    Dominance

f) The resulting B-IBI will both classify and be able to distinguish landscape-level sources (causes) of impaired stream condition across a range of "moderately-impaired" conditions, in addition to the more obvious "nearly-undisturbed" and "severely degraded".

Assumptions:

1. The composition of stream benthic macroinvertebrate communities responds to natural and human-induced disturbance in a consistent fashion and to such a degree, when understood, as to permit consistent inference as to the general nature of the causes of such disturbance at the level of the surrounding landscape.
2. Current sampling and analysis procedures permit enough of the relevant signal of landscape disturbance impacts on stream health that is contained in benthic invertebrate community response to be retrieved and reflected by a multi-metric index.
3. There exists enough detailed and accessible information regarding human-induced landscape disturbance of stream conditions in the Yakima/Naches basins to enable the information regarding stream health which is contained in benthic invertebrate community composition and retrieved by multi-metric analysis to be tested and validated within the proposed project period.

Other Related Outcomes Expected:

We hypothesize and expect that information contained in a validated B-IBI will also be capable of providing significant summary information regarding the status of the basic food web of stream reaches surveyed. This information, particularly when integrated with other proposed or ongoing projects in the Yakima subbasin regarding habitat conditions and processes and fish populations, will greatly further the goal of understanding normative conditions and how to achieve them.

Products:

An initial Progress Report would be produced by May 2001 and semi-annual "milestone" reports in May of 2003 and 2005. Some results would be written up by the Project Director and/or by or in collaboration with Dr. James Karr and published in peer reviewed publications such as the Journal of the North American Benthological Society. Slide show presentations would be given to relevant management agencies and other interested parties in the Yakima Basin and elsewhere, including NPPC and relevant caucuses of CBFWA. Data would be placed into an Access database and a GIS system database from which it would be available to interested parties.

f. Methods

30 riffle sample sites will be chosen. These sites will include at least 20 tributary streams as well as at least one site each on the mainstem Yakima downstream of the confluence of the Naches, the mainstem of the Naches, and the mainstem of the Upper

Yakima. Three (3) replicate samples will be collected from subsites within each riffle using Surber Samplers fitted with 500 micron Nytex netting. A total of 90 replicates will therefore be collected each year. Field sampling protocols standardized by Dr. James Karr and colleagues will be employed, as referenced above in subsection “e”.

The Project Director and a graduate student working under Dr. Karr and hired under the proposed project will do all field sampling. Each riffle sample site will be marked with GPS, a channel cross-section surved and monumented to a nearby landscape feature to permit ready re-location of sample sites in subsequent seasons.

Benthic macroinvertebrates from each replicate sample will be completely enumerated and identified primarily to the level of genus. The majority of samples will be sorted, enumerated and identified by the Project Director and a graduate student of Dr. James Karr at laboratory facilities provided by Dr. Karr at the University of Washington. Some samples will be sorted, enumerated, and identified or made ready for identification to genus by the Project Director at Washington Trout’s office in Duvall, Washington.

Identification to the level of genus has been found sufficiently precise for determining taxa response to various levels and kinds of habitat disturbance (Karr and Chu 1997, and Dr. James Karr, personal communication). Sub-sampling of replicates will not be done as it has been determined to be defeating of the aims of developing a sensitive B-IBI, and does not result in an appreciable or efficient saving of sample-identification time. The individual metrics to be evaluated and from which the final components of the multi-metric index are chosen are most reliable when replicates contain a minimum of 500 individuals and when replicates are not pooled to attain this number. Laboratory time to sort and identify each replicate will average 6 hours.

Sample collection is done during baseflow during the early fall to minimize seasonal effects, insure safe and easy collection conditions, and because it is a time of generally high abundance of most aquatic invertebrates. Sampling is also timed to precede chinook salmon spawning. Riffles are chosen because they are sources of high invertebrate abundance, and because they are shallower and easier to sample than pools, and are more readily and consistently identifiable by field crews.

The general process of developing and evaluating metrics for B-IBIs are well-presented in Fore et al., 1996, and briefly summarized here. Individual candidate metrics (examples of which are enumerated in “e” above) start out as hypotheses about how invertebrates respond to disturbances. Metric testing then proceeds in an iterative fashion, comparing each metric’s response across a range of known disturbance conditions. Metrics are re-evaluated and refined as more regional data covering a broader range of disturbance conditions becomes available and/or as a broader range of such conditions in the region is sampled. Graphical analysis is relied on more or less equally with standard moment statistical analysis to evaluate the sensitivity of candidate metrics to track ranges of disturbance.

The resulting multi-metric index is a sum of individual metrics, each of which bears a score of 1, 3, or 5 (for “severely degraded”, “moderately degraded”, and “nearly pristine/pristine”). Criteria according to which a particular metric receives a 1, 3, or 5 is determined by evaluating that particular metric’s actual values (e.g., “number of Ephemeroptera taxa”) across the range of documented disturbance conditions of the total pool of sample-site catchments, and partitioning those values at breaks between the three general disturbance conditions. Candidate metrics whose actual value trajectories fail to display a reasonably clear gradient in actual values across the range of disturbance conditions are rejected.

The maximum index score will be 5 times the number of individual metrics, the minimum score will be 1 times the number of metrics. If there are ten (10) metrics, possible scores can range from 10 to 50. Sites are then evaluated (scored) with the multi-metric on the basis of the total, summed, index score. The multi-metric index is then evaluated both for its accuracy in ranking sites and for its sensitivity in distinguishing categories (levels) of disturbance. Statistical power analyses of extant fish-IBIs used in the mid-west indicate that IBI can detect six (6) distinct categories of biological condition (reported in Karr and Chu, 1997).

Regional data bases of land management agencies, such as USGS, USFS, USBR, WDFW, DNR, DOE, and YIN and their staffs will be queried to determine a representative sample of combinations of stream conditions and surrounding land-use patterns from which the 30 stream sites will be chosen. In addition, the Project Director already possesses knowledge of several likely sampling sites as a result of field work in the upper Yakima and Naches basins under Washington Trout's native resident trout survey project during FY1998 (BPA project #98-026).

As noted in sub-section "e" (Hypotheses to be tested 'e'), we expect to construct a reliable multi-metric index consisting of 10 to 12 individual metrics. Monitoring and evaluation of the initial multi-metric will occur during the course of the proposed project in several ways:

Year-to-year changes at sites will be correlated with annual changes in associated land-use conditions and climatological data.

By the third year, if not during the second, we would endeavor to create a kind of blind test of the following sort: have an independent field crew sample up to three new stream sites within the Yakima Basin using the requisite collection protocols. We would process the samples, apply the multi-metric and predict the condition of the stream and associated landscape. Alternatively, we would have a third party knowledgeable of the B-IBI make this kind of evaluation from the data we would derive from collections from the new sites.

Results from the proposed project during the course of the project and after would be compared and integrated with results from other studies noted in subsection "c" above and with related population and habitat evaluation studies which we plan to propose for FY2000 and/or following FYs.

g. Facilities and equipment

Washington Trout possesses vehicles for transportation to and from sampling sites. Surber samplers and 500 micron brass sieves necessary for the field collection are specifically included in the project budget. Other sampling equipment and supplies are either in Washington Trout's possession or included in the budget request. Computers and statistical and other software are in hand, with the exception of a laptop PC which is discussed below.

As noted in subsection "f" above, laboratory facilities and resources at the University of Washington appropriate for processing field invertebrate samples, including identification to appropriate taxonomic level, will be provided by Dr. James Karr, who will also provide advice and assistance to the Project Director, in addition to supervising graduate student training facilitated in part by the proposed project. These services are a match to the project provided by Dr. Karr and discussed further under sub-section "h" below.

Washington Trout also has ample work space to allow the Project Director to engage in sample sorting, preparation for identification, and identification to genus at Washington Trout's office in Duvall, Washington. Many of the appropriate invertebrate identification keys are in the personal possession of the Project Director; others are readily obtainable by purchase or photocopy.

Washington Trout will require a good quality research microscope for this work and this is included in the budget request. Having the ability to preliminarily sort field samples and to fully identify individual organisms at the Washington Trout office will promote the efficient use of the Project Director's time and promote project efficiency.

Sampling protocols include recording stream and air temperatures during sampling as well as taking basic habitat unit measurements. As noted above location will be recorded with GPS. Undertaking extensive sampling in the Yakima subbasins over a narrow (~30 day) period of time will make it possible for the field crew to place temperature data loggers in many of the streams to be sampled and in the nearby riparian zone for several days or weeks. Use of a hand-held thermocouple with probe will permit groundwater upwelling sites in the riffle reaches sampled to be identified and temperature inputs from upwelling areas compared to ambient stream water temperatures in the reaches. The use of a laptop PC will enable GPS data to be directly downloaded in the field and will allow temperature loggers to be downloaded and then reset for sampling at other sites, in addition to facilitating other project-related computer activities to be undertaken away from the office.

h. Budget

Personnel costs include 30 8-hr. days for two (2) persons for field collecting (total of 480 hours), and 6 hours per replicate sample for sorting and identification of invertebrates (total of 540 hours). An additional 100 hours are budgeted for data/results analysis, report writing and related communications by the Project Director. The total of 1120 hours will be paid at the rate of $20/hr. for a sub-total personnel budget of $22,400. Benefits are calculated at 25% (=$5600), for a total personnel budget of $28,000.

Dr. James Karr estimates a contribution of two weeks of his time to assist with various aspects of the project and values this time at $6,000. This is a cost-share contribution. Value has not been calculated for access to laboratory facilities at the University of Washington under the direction of Dr. Karr, but is likely not inconsiderable and is an additional match to the project.

Supplies include paper and computer supplies (Zip and floppy discs), field notebooks, etc., preservative chemicals and containers for invertebrate specimens and similar field collection materials.

Vehicle maintenance includes funds for field work related body damage, tire wear, lubrication, and tune-ups.

Capital equipment expenditures are for 1 research microscope, 1 laptop computer, 4 Stowaway 8k temperature loggers, 2 Surber samplers, 2 500-micron brass sieves, 2 100-, foot field measuring tapes and 4 heavy-duty hand clamps, and one hand-held digital thermocouple with probe and 5' extension cord.

Travel costs include an estimated 5000 miles transportation to and from field sampling sites (at $0.35/mi.), food for 2 persons for 30 days field work (at $20/person/day), an estimated maximum of 5 nights motel lodging for 2 persons at $60/night, and $600 for one horsepack trip into the upper Bumping River (Naches R. basin) in the William O. Douglas Wilderness Area.

Section 9. Key personnel

A graduate student in biology or zoology working under Dr. James Karr would be hired by Washington Trout to assist the Project Director in both the field collection and in the laboratory work of sorting and identifying collected macroinvertebrates. This person would be chosen and recommended by Dr. Karr and would possess all skills requisite for the work, a large portion of which would be overseen by Dr. Karr as a normal part of the graduate student's course and/or thesis work.

The Project Director, Nick Gayeski, would make up the other half of the two-person field and laboratory crew. Mr. Gayeski has a Masters Degree in Philosophy from the University of Washington where his primary area of interest was the philosophy of science. He has had a longstanding avocational interest in aquatic biology, including macroinvertebrate ecology, salmonid life history, and population biology. He is well-aquainted with the professional peer-reviewed literature in these fields and in related fields of aquatic biology and fisheries management, and maintains currency with this literature. He has extensive experience in the collection of freshwater macroinvertebrates and has taught numerous field courses in macroinvertebrate identification for fly anglers for professional fly-fishing retail stores in the Northwest.

For the past three years he has been employed fulltime by Washington Trout, where his primary duties have been grant writing and public fisheries and landscape management policy evaluation. He is the Director for BPA Project #98-026, which has proposed to photo-document native resident trout populations throughout the mid- and upper-Columbia Basins in Washington State and to collect tissue samples from these populations for nuclear DNA analysis.

Recent additional experience and training includes the following:

Organizing and hosting a day-long public/scientific forum on "Addressing Risk and Uncertainty in Salmonid Harvest Management" held in Olympia, Washington in January of 1998;

Participation in the "Aquatic Oligochaete Workshop" held in Logan, Utah in September of 1997 and conducted by Drs. Deedee Kathman and Ralph Brinkhurst of Aquatic Resources Center in Franklin, Tennessee. The Workshop was co-sponsored by the Whirling Disease Initiative for the National Partnership on Management of wild and Native Cold Water Fisheries, and included field training in the collection of aquatic oligochaete worms and laboratory training in slide preparation of oligochaetes and the use of microscope and key to identify them to genus and species.

Participation in a training course on "Ground Water-Surface Water Interaction" held in September of 1998 at the University of Montana's Flathead Lake Biological Station and conducted by Dr. Jack Stanford, Director of the Biological Station.

Section 10. Information/technology transfer

Information and results from the project will be provided in the form of progress and semi-annual "milestone" reports to CBFWA/NPPC, peer-reviewed scientific journal articles, reports in Washington Trout's newsletter, the Washington Trout Report, and on Washington Trout's web site. Informational slide-show presentations will be made to be given to regional managers in the Yakima and other subbasins, relevant sub-committees of the Timber, Fish, and Wildlife Forum, and other interested parties. Data will be placed in an Access database where it can be made available to members of CBFWA and others. Data will also be incorporated into Washington Trout's GIS system, where it can also be made available to interested parties.

Congratulations!